Effect of Chromium and Tanning Method on the Drape of Goat Suede Apparel Leathers

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Abstract

Tanning stabilizes the skin matrix permanently and is considered as the heart of leather processing. In commercial practice, vegetable and chrome tanning methods are widely employed. Between these two methods, chrome tanning is the most commonly used tanning method. Hence, it is logical to study the relationship between the chromium content and drape related properties of garment leathers. In this study, the bending length and drape parameters were measured for goat suede leathers with different chromium contents and analyzed. The goat suede leathers were prepared in three different ways namely full chrome (FC), semi chrome (SC) and full vegetable (FV) methods. Whereas FC and FV goat suede leathers had increasing drape coefficient values, the drape coefficient for SC goat suede leathers was the lowest in the range of 35.1±7.2%. Further, softness, bending length and number of nodes for SC goat suede leathers were statistically superior in the stand point of drape ability compared to FC and FV goat suede leathers. Hence, it is validated that the semi chrome goat suede leathers possess better drape ability compared to full chrome as well as full vegetable goat suede leathers. Consequently, the presence of chromium in the leathers plays a major role in the draping ability of goat suede apparel leathers; however, it is also inferred that more amount of chromium in the leathers (FC) did not yield better drape ability.

Resumen

La curtición estabiliza permanentemente la matriz de la piel y es considerada como el corazón del procesamiento del cuero. En la práctica comercial, los métodos de curtición al vegetal y al cromo son ampliamente empleados. Entre estos dos métodos, el curtido al cromo es el método más comúnmente empleado de curtición. Por lo tal es apenas lógico el estudiar la relación entre el contenido de cromo y las propiedades relacionadas con la "caída" en cueros para vestimenta. En este estudio, la longitud del doblegado y los parámetros pertinentes a la denominada "caída" del cuero fueron determinados en cabros agamuzados para vestimenta conteniendo diferentes cantidades de cromo y analizados. Los cueros de cabro agamuzados fueron preparados en tres formas diferentes; es decir, puro cromo (FC), semi-cromo (SC) y solo vegetal (FV). Mientras que FC y FV cueros de cabro para vestimenta demostraron incrementados coeficientes de "caída", el coeficiente de "caída" para los cueros SC de cabros agamuzados fue el más bajo con un rango de 35,1 ± 7,2 . Más aun, la blandura, la longitud del doblegado y número de nodos para cueros de cabros agamuzados SC fueron estadísticamente superiores desde el punto de vista de capacidad para vestir en comparación con los cueros de cabro agamuzados de FC y FV. Es decir, que queda establecido que el cuero de cabro agamuzado semi-cromo posee mejor capacidad de vestir comparado a los cueros agamuzados de cabro curtidos al solo cromo y solo tanino. Por consecuencia, la presencia de cromo en los cueros juega un papel principal en la capacidad de cubrir en los cueros de cabro para vestimenta; sin embargo, se infiere que la más cantidad de cromo en los cueros (FC) no produjo las mejores características para vestir.

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INTRODUCTION

Leather processing may be classified in three groups, namely, pretanning or beam house operations, tanning and post tanning.[1,2] Tanning is a process in which the protein in the skin is permanently stabilized against heat, enzymatic degradation and thermo-mechanical stress.[3] In commercial practice, vegetable and chrome tanning methods are widely employed. Between these two methods, chrome tanning is the most commonly used tanning method because it offers excellent properties to the leather namely softness, hydro-thermal stability, dyeability, grain smoothness, light weight, stretch etc. Further chrome tanning has the potential to make versatile leathers for a variety of applications unlike vegetable tanning. More than 90% of the leathers processed globally contain chromium.[4,5] Therefore, it is worthwhile to study the relationship between the chromium content and physical properties of final leather.

Many researchers have studied the strength and related properties of leathers as a function of type of tannage or chromium content in leather.[6-10] De Brito et al[6] studied the properties of goat skins tanned using trivalent chromium salts after retanning with aldehyde. They concluded that the percentage of chromium present in the leather made significant effect on the physical properties such as tensile and tear strength. It has also been shown that the strength of chrome tanned leather decreases as its chrome content increases.[9]

The most important characteristic of clothing leather of any type is its ability to drape well. This property also known as fall, is important because this contributes to wear comfort also. Drape is the property that affects the aesthetic appeal and functionality of materials used for clothing manufacture. It can be used to determine the adjustment of clothing to the human body.[11] Chu et al[12] described drape as the way that a fabric hangs or falls over a three dimensional form in response to the force of gravity. To the best of the authors' knowledge, no study was carried out to find the relation between the chrome content of the leathers and their drape properties. Goat suede leathers possess better drape ability compared to other apparel leathers such as sheep nappa and cow nappa.[13-15] Goat suede leathers can be used in apparels requiring more fall, flexibility and textile like clothing. In this study, the bending length, drape coefficient and number of nodes were measured for goat suede leathers with different chrome contents and analyzed.

EXPERIMENTAL

Materials: Commercially available wet blue (tanned using 8% basic chromium sulfate) and vegetable tanned (tanned using 20% wattle powder) goat leathers of Indian origin with fairly uniform size of 4±1 sq.ft. and thickness of 1.0±0.1 mm were procured. The goat leathers were processed into garment suede in three different ways as shown in Appendix I at M/s Vikram Tanners, Chennai and the leathers were designated as FC, SC and FV for the respective processes namely full chrome, semi chrome and full vegetable.

Method, Measurement and Calculation: Amount of chromium in the crust leathers was determined by quantification of chromic oxide content and the value is expressed as percentage by weight.[16] Samples from these leathers in each process were cut, analyzed and averaged.

Ten leathers were chosen from each experiment and two circular samples were taken from each leather type for the drape coefficient measurement. The drape coefficient (DC) was determined according to IS 8357 using Bombay Textile Research Association drape meter.[17] A circular leather specimen (25 cm) was sandwiched between two horizontal discs of smaller diameter (12.5 cm), and the unsupported annular ring of fabric was allowed to hang down under the action of gravity. A planar projection of the contour of the draped specimen was recorded on a light sensitive paper. The drape pattern obtained was cut along the outline and its area was determined gravimetrically. The drape coefficient was calculated (based on Cusick's method[18]) as a ratio of the projected area of the drape specimen to its theoretical maximum as given below.

$$\textit{Drape coefficient}\ (DC\%) = \frac{\frac{w}{W} - a}{A - a} \times 100 \qquad (1)$$

Where W = Mass per unit area of the paper
w = Mass of the drape pattern
a = Area of circle of 12.5 cm diameter = 122.8 cm^2
A = Area of circle of 25 cm diameter = 491.1 cm^2

The drape coefficient was expressed as a percentage. A low value of DC indicates easy deformation and good drape ability of leather and a high value of DC indicates less deformation and poor drape ability. Very stiff leather has a drape coefficient close to 100%, whereas very limp leather has one close to 0%. Number of nodes present in the contour of the drape profile was also recorded for each sample. The drape coefficient values decrease with the increase in number of nodes, in other words, lesser value of drape coefficient and higher value of number of nodes indicate better drape ability.

From the circular samples used for drape coefficient measurement, rectangular samples were cut along and across backbone directions for measurement of bending length. Bending length equals half the length of rectangular strip of fabric/leather that will bend under its own weight to an angle of 41.5°. Size of the test specimens were 25x200 mm.

Bending length was determined following Peirce's method using Synthetic and Art Silk Mills Research Association (SASMIRA) stiffness tester according to IS 6490.[19] Low value of bending length indicates low stiffness which means better drape ability and a high value of bending length indicates high stiffness or poor drape ability. The tensile strength and % elongation at break of the processed leathers were measured using standard procedure after conditioning.[20]

Softness of the leathers was determined following IUP 36 test method[21] using ST 300 digital leather softness tester. Softness was expressed in mm of leather deflection. The size of the reducing ring used in the softness tester was 20 mm. Softness values were measured in four positions and the mean values were calculated for each sample. Thickness was measured according to IS 5914.[20] Thickness was measured in four positions and the mean value was calculated for each sample. Weight of the leather samples were measured using an electronic balance with an accuracy of 0.01gm.

RESULTS AND DISCUSSION

The chromium content, tensile strength and percentage elongation at break values of FC, SC and FV goat suede leathers are shown in Table I. It is seen that the chromium content of FC and SC goat suede leathers are normal and comparable to the values reported earlier.[22,23] It is surprising to note that FV goat suede leathers do possess very small amount of chromium. This may be due to the presence of chromium in the chosen dyes or the interference of post tanning chemicals during the analysis of chromium. The tensile strength of FC and FV goat suede leathers is fairly similar while that of SC goat suede leathers is statistically higher. It is seen that the presence of moderate amounts of chromium and vegetable tannins provide better strength to leather matrix, however, leathers tanned completely with either chromium or vegetable tannins do not posses higher tensile strength. On the other hand, percentage elongation (at break) values increase as a function of the amount of chromium present in the leather matrix as seen from the Table I.

The bulk properties such as weight per unit area, softness and thickness of goat suede leathers processed through full chrome, semi chrome and full vegetable are given in Table II. It is observed that the mean weight per unit area of FC and SC leathers are significantly lower compared to FV leathers. This may be attributed to the presence of vegetable tannins in the FV leather, which loads the matrix. It is also seen that the mean thickness for all the leather samples (FC, SC and FV) is around 0.6 mm. Since the variation in the thickness of different types of goat suede leathers is negligible, it is expected that thickness may not influence drape coefficient significantly. The mean softness values of the FC and SC leathers indicate that there is no significant change in softness between FC and SC leathers. The mean softness of FV leathers is 4.44 mm. It is known that the vegetable tanned leathers are generally harder than the chrome tanned leathers.[24] The softness values of individual goat suede leather samples (FC, SC and FV) have been plotted and fitted for straight line as shown in Fig. 1. The numbering of the leather samples in the plot was arbitrary. It is seen that the softness of FV

TABLE I

Chromium Content and Tensile Properties of Goat Suede Leathers Processed Through Full Chrome, Semi Chrome and Full Vegetable Methods

Samples	Tensile strength (MPa)	% elongation at break	Chromium content, % Cr_2O_3 (weight basis)
FC			
Mean	14.8	59.5	4.05
SD	3.6	4.1	0.4
n	10	10	3
SC			
Mean	18.8	54.7	1.65
SD	1.3	2.2	0.3
n	10	10	3
FV			
Mean	14.6	40.7	0.2
SD	3.0	3.5	0.05
n	10	10	3

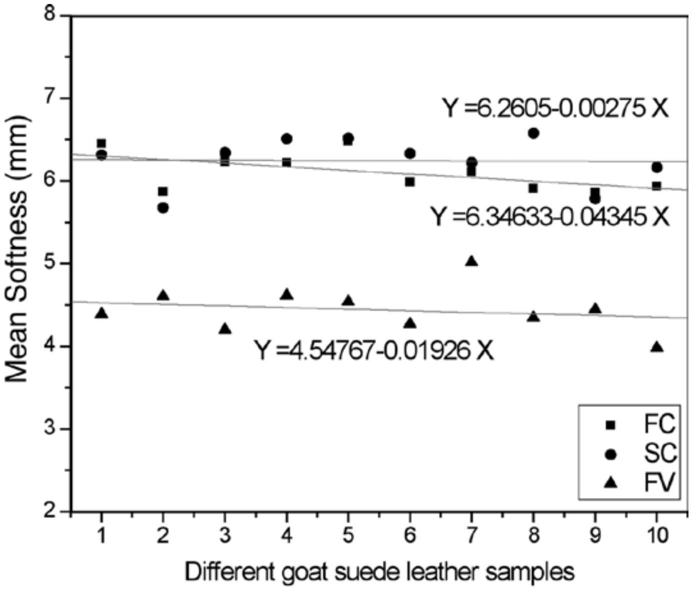

Figure 1. – Plot of mean softness of individual goat suede leather samples processed through full chrome, semi chrome and full vegetable methods.

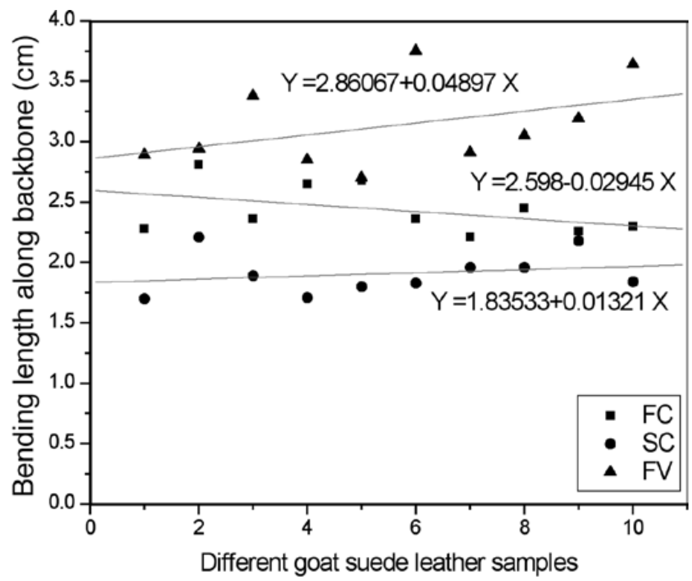

Figure 2. – Plot of mean bending length (along backbone) of individual goat suede leather samples processed through full chrome, semi chrome and full vegetable methods.

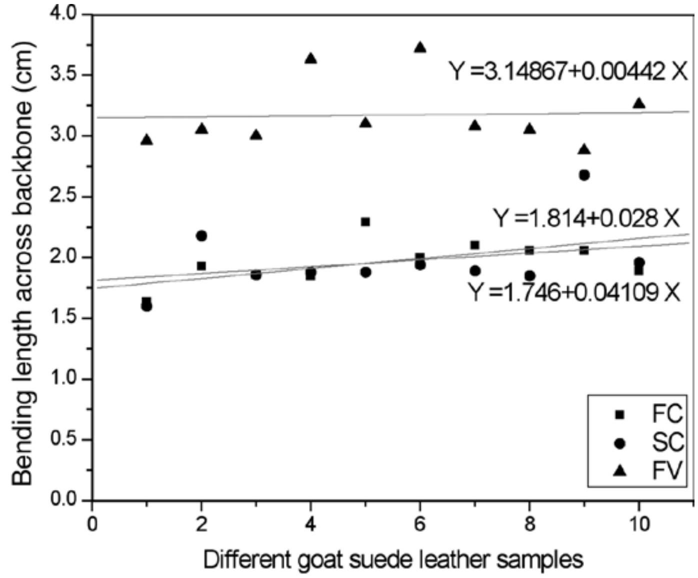

Figure 3. – Plot of mean bending length (across backbone) of individual goat suede leather samples processed through full chrome, semi chrome and full vegetable methods.

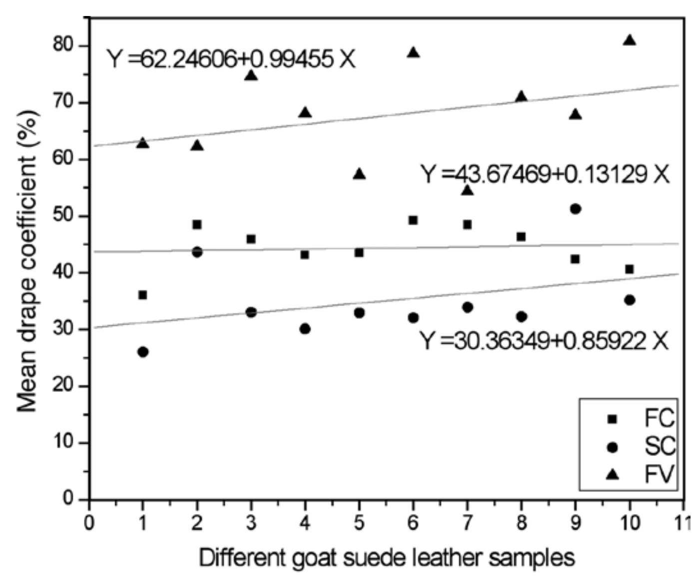

Figure 4. – Plot of mean drape coefficient of individual goat suede leather samples processed through full chrome, semi chrome and full vegetable methods.

leathers is significantly less compared to FC and SC leathers. It is interesting to note that the intercept of the derived line equations directly relates to the average values obtained for each type of goat suede leathers, as seen from Table II. However, such a relation is not pronounced in the case of FC goat suede leathers.

The bending length and drape parameters of FC, SC and FV goat suede leathers are given in Table III. It is observed that the mean bending length values of semi chrome leathers are less compared to full chrome and full vegetable goat suede leathers in both the backbone directions. Overall, full vegetable goat suede leathers possess higher bending length compared to other two types of leathers. While there is not much variation in bending length values between along and across backbone directions for semi chrome and full vegetable goat suede leathers, the full chrome goat suede leathers show higher bending length values along backbone direction compared to across backbone. The bending length values of individual FV, SC and FV goat suede leathers are plotted in

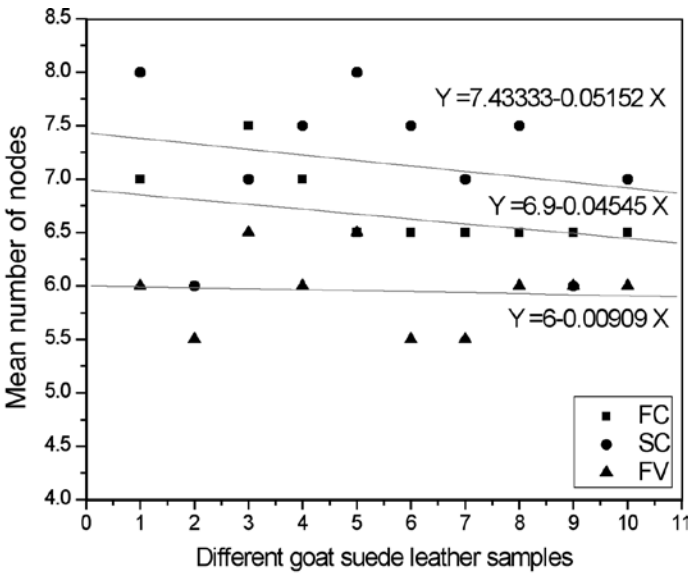

Figure 5. – Plot of mean number of nodes of individual goat suede leather samples processed through full chrome, semi chrome and full vegetable methods.

TABLE II

Bulk Properties of Goat Suede Leathers Processed Through Full Chrome, Semi Chrome and Full Vegetable Methods

Samples	Weight per unit area (gm/dm^2)	Thickness (mm)	Softness (mm)
FC	2.88±0.32	0.61±0.05	6.11±0.23
SC	3.04±0.33	0.61±0.05	6.25±0.30
FV	3.86±0.49	0.58±0.07	4.44±0.28

Number of samples (n) = 10; The values are average of ten samples along with standard deviation.

TABLE III

Bending Length and Drape Parameters of Goat Suede Leathers Processed Through Full Chrome, Semi Chrome and Full Vegetable Methods

Samples	Bending length (cm)		Drape coefficient (%)	Number of nodes*
	Along Backbone	Across Backbone		
FC	2.44±0.21	1.97±0.18	44.4±4.1	6.5±0.5
SC	1.91±0.18	1.97±0.29	35.1±7.2	7.0±0.5
FV	3.13±0.35	3.17±0.28	67.7±8.8	6.0±0.5

Number of samples (n) = 10; The values are average of ten samples along with standard deviation;
*In the case of number of nodes, the average values were rounded off to 0.5 for ease of understanding.

Fig. 2 and 3 for along and across backbone samples, respectively. The numbering of the leather samples in the plots was arbitrary. The plots were fitted for linear equation. It is seen that, similar to softness plots, the intercept values of the line equation can be directly related to the average values of bending length for each goat suede leather types, as seen from Table III. Again intercept values of full chrome goat suede leathers along backbone is statistically higher than that of across backbone value. Comparing all the leather types, the semi chrome goat suede leathers have lower bending length values and hence possess better drape ability.

It is seen form the Table III that the mean drape coefficient of semi chrome goat suede leather is the lowest compared to full chrome and full vegetable goat suede leathers. Similarly, the mean number of nodes formed in the case of semi chrome goat suede leathers is the highest compared to full chrome and full vegetable goat suede leathers. The drape confident and number of nodes are inversely related for goat suede leathers.[14] The mean drape parameters obtained for semi chrome goat suede leathers are comparable to the values reported earlier.[14] Hence, it is inferred that the semi chrome goat suede leathers possess better drape ability compared to full chrome goat suede leathers. These results are surprising. Because, in general, full chrome leathers are preferred for apparel application compared to semi chrome or full vegetable leathers. This is because full chrome leathers generally offer light weight and hence expected to give better drape ability. It is shown that a decrease in the weight of leather (sheep nappa and goat suede) leads to decrease in drape coefficient and better drape ability.[13,14] Intriguingly, the mean weight per unit area of SC goat suede leather is statistically higher (6%) than that of FC goat suede leathers. Nevertheless, the mean drape coefficient values of SC goat suede leathers is 21% lower than that of FC goat suede leathers. This weight versus drape coefficient relation is contradicting to the earlier reports.[13,14] Similar trends are noted for the number of nodes. This may be due to the fact that SC goat suede leathers contain smaller amount of vegetable tannins whereas FC goat suede leathers are almost empty and porous. These excess vegetable tannins increase the weight per unit area and hence may help in decreasing drape coefficient. This is because drape measures the material's ability to fall under the force of gravity. Thus, a slight increase in the weight of SC goat suede leather assists in more "fall" or bending of the material. On the other hand, when there is more increase in the weight of the leather, the drape coefficient value increases significantly, as seen in FV goat suede leathers. Hence, it may be deduced that a slight increase in weight or filling of the porous matrix is beneficial for achieving higher drape ability. In other words, too high or too low chromium content in the leather matrix is unfavorable for the drape ability of the leathers.

The mean drape coefficient and the number of nodes of individual goat suede leather samples were plotted for all processing types (FC, SC and FV) as shown in Fig. 4 and 5, respectively. The numbering of the leather samples in the plots was arbitrary. The points were fitted linearly. As can be seen, the intercept values closely matches with the mean drape coefficient and mean number of nodes obtained for each leather types, as seen from Table III. Hence, this study also demonstrates that the intercept of a line equation can be directly related to the average or mean of a given parameter, at least from the present set of data.

CONCLUSIONS

In order to find the relation between chrome content and drape ability of goat suede apparel leathers, the leathers were processed through three groups namely full chrome, semi chrome and full vegetable. The bending length and drape parameters such as drape coefficient and number of nodes were measured and compared for all the types of goat suede leather samples. The semi chrome leathers possess better drape ability compared to full chrome and full vegetable leathers. The SC leathers exhibited lowest drape coefficient and bending length and highest number of nodes compared to FC and FV leathers. The softness values of SC and FC goat suede leathers are almost similar but that of FV leathers are less. When the individual values of drape parameters were plotted and fitted linearly, it was seen that the intercept values of the line equations were comparable to the mean values of all the drape parameters. It is demonstrated that too high or too low chromium content in the leathers does not favor better draping of suede garment leathers. The findings of this study can be used as a tool for selection of proper processes and leathers for apparel application.

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APPENDIX I

Full Chrome, Semi Chrome and Full Vegetable Process Details for Preparing Goat Suede Garment Leathers

Full Chrome Crust Leather Making		
Raw material: Chrome tanned goat leathers (Wet blue leathers). The wet blue leathers were sammed and shaved on grain side to a thickness of 0.8±0.1 mm. The shaved weight was noted. All the percentages based on the shaved leather weight.		
Process/chemicals	**%**	**Duration/Remarks**
Wet Back		
Water	200	
Wetting agent	0.75	Run 30 min; Drained out.
Rechroming		
Water	50	
Formic acid	0.3	Run 10 min.
Basic chromium sulfate	5	Run 30 min.
Chrome syntan	5	Run 30 min.
Aluminum syntan	3	Run 20 min.
Colloidal acrylic syntan	3	Run 20 min.
Sodium formate	2	Run 30 min.
Sodium bicarbonate	2	3 ×10 min + Run 40 min; Drained out.
Neutralization		
Neutralizing syntan	1	Run 30 min.
Sodium formate	2	Run 30 min.
Sodium bicarbonate	1.5	3 ×10 min + Run 45 min; Cross-section pH was found to be 5.5±0.2; Bath was drained out.
Washing I		
Water	200	Run 10 min; Drained out.
Washing II		
Water	200	Run 10 min; Drained out.
Post tanning		
Water	50	
Acrylic syntan	3	Run 30 min.
Protein syntan	3	Run 30 min.
Phenol condensed syntan	3	Run 30 min.

Vegetable based fatliquor	2	
Semisynthetic fatliquor	2	
Synthetic fatliquor	3	
Lecithin based fatliquor	3	Run 30 min; Fatliquors emulsified in 10% hot water at 60°C.
Phenol condensed syntan	10	Run 40 min.
Melamine resin syntan	4	Run 30 min.
Fixing		
Formic acid	3	3 ×10 min + Run 60 min; Acid diluted in 10% water; Drained out.
Washing		
Water	200	Run 10 min; Drained out and piled overnight.
Next day, leathers were set and hooked for drying. The dried leathers were conditioned, staked, trimmed and buffed using 180, 240, 400 and 600 emery papers.		
Semi Chrome Crust Leather Making		
Raw material: Vegetable tanned goat leathers (East India (EI) leathers). The EI leathers were conditioned and shaved on grain side to a thickness of 0.8±0.1 mm. The shaved weight was noted. All the percentages based on the shaved leather weight.		
Process/chemicals	**%**	**Duration/Remarks**
Wet Back		
Water	200	
Wetting agent	0.5	Run 30 min; Drained out.
Stripping		
Water	100	
Degreasing agent	2	
Wetting agent	1	
Borax	1	Run 60 min; Drained out.
Bleaching		
Water	100	
Oxalic acid	2	
Bleaching syntan	2	Run 40 min; Drained out.
Washing		
Water	200	Run 10 min; Drained out.
Chrome tanning		
Water	50	
Basic chromium sulfate	15	Run 60 min.

Aluminum syntan	3	Run 30 min.
Water	50	Run 30 min.
Sodium formate	2	Run 30 min.
Sodium bicarbonate	1.5	3 ×10 min + Run 40 min; Cross-section pH was found to be 3.8±4.0; Bath was drained out.
Washing		
Water	200	Run 10 min; Drained out.
Neutralization		
Water	150	
Neutralizing syntan	2	15’
Sodium formate	1	Run 30 min.
Sodium bicarbonate	0.5	3 ×10 min + Run 45 min; Cross-section pH was found to be 5.5±0.2; Bath was drained out;
Washing I		
Water	200	Run 10 min; Drained out.
Washing II		
Water	200	Run 10 min; Drained out.
Post tanning		
Water	100	
Colloidal acrylic syntan	2	Run 30 min.
Acrylic syntan	2	Run 30 min.
Vegetable based fatliquor	3	
Synthetic fatliquor	3	Run 45 min; Fatliquors emulsified in 10% hot water at 60^{o}C.
Protein syntan	3	Run 30 min.
Phenol condensed syntan	8	Run 45 min.
Melamine resin syntan	2	Run 30 min.
Fixing		
Formic acid	2	3 ×10 min + Run 60 min; Acid diluted in 10% water; Drained out.
Washing		
Water	200	Run 10 min; Drained out and piled overnight.
Next day, leathers were set and hooked for drying. The dried leathers were conditioned, staked, trimmed and buffed using 180, 240, 400 and 600 emery papers.		

Full Vegetable Crust Leather Making		
Raw material: Vegetable tanned goat leathers (East India (EI) leathers). The EI leathers were conditioned and shaved on grain side to a thickness of 0.8±0.1 mm. The shaved weight was noted. All the percentages based on the shaved leather weight.		
Process/chemicals	**%**	**Duration/Remarks**
Wet Back		
Water	200	
Wetting agent	0.5	Run 30 min; Drained out.
Stripping		
Water	100	
Degreasing agent	2	
Wetting agent	1	
Borax	1	Run 60 min; Drained out.
Bleaching		
Water	100	
Oxalic acid	1	
Bleaching syntan	1	Run 40 min; Drained out.
Washing		
Water	200	Run 10 min; Drained out.
Neutralization		
Water	150	
Neutralizing syntan	2	15’
Sodium bicarbonate	0.5	3 ×10 min + Run 45 min; Cross-section pH was found to be 4.8±0.2; Bath was drained out.
Washing I		
Water	200	Run 10 min; Drained out.
Washing II		
Water	200	Run 10 min; Drained out.
Post tanning		
Water	100	
Phenol condensed syntan	4	
Melamine resin syntan	3	Run 45 min.
Protein syntan	4	Run 30 min.
Synthetic sperm oil fatliquor	3	

Lecithin based fatliquor	2	
Synthetic fatliquor	2	Run 45 min; Fatliquors emulsified in 10% hot water at 60°C.
Fixing		
Formic acid	2	3 ×10 min + Run 60 min; Acid diluted in 10% water; Drained out.
Washing		
Water	200	Run 10 min; Drained out and piled overnight.
Next day, leathers were set and hooked for drying. The dried leathers were conditioned, staked, trimmed and buffed using 180, 240, 400 and 600 emery papers.		
Conversion of Full Chrome, Semi Chrome and Full Vegetable Crust Leathers into Garment Suede Leathers		
Raw material: Full chrome, semi chrome and full vegetable goat crust leathers. The weight of the crust leathers was noted. All the percentages based on the crust leather weight.		
Process/chemicals	**%**	**Duration/Remarks**
Wet Back		
Water	600	
Wetting agent	0.5	
Ammonia	1	Run 90 min; Drained out.
Bleaching		
Water	200	
Oxalic acid	1	
Bleaching syntan	1	Run 40 min; Drained out.
Washing		
Water	300	Run 10 min; Drained out.
Dyeing and fatliquoring		
Water	200	
Aluminum syntan	2	Run 20 min.
Phenol condensed syntan	2	Run 20 min.
Neutralizing syntan	2	Run 20 min.
Sodium bicarbonate	1	3 ×10 min + Run 30 min; Cross-section pH was found to be 5.5±0.2.
Dye leveling agent	1	Run 10 min.
Dye	3	Run 30 min.
Vegetable based fatliquor	3	
Semisynthetic fatliquor	6	
Synthetic fatliquor	6	

Lecithin based fatliquor	3	
Odorless fish oil fatliquor	3	Run 90 min; Fatliquors emulsified in 10% hot water at 60°C.
Fixing		
Formic acid	3	3 ×10 min; Acid diluted in 10% water.
Cationic fatliquor	1	Run 40 min; Drained out.
Washing		
Water	200	Run 10 min; Drained out and piled overnight.
Next day, leathers were hooked for drying. The dried leathers were toggled and dry drummed for 6 h.		